ASSESSMENT OF THE ECONOMIC AND ENVIRONMENTAL SUITABILITY OF THE JIU-CORABIA ENCLOSURE FOR LAKE USAGE USING GIS TECHNIQUES

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Abstract
One of the three strategic objectives of the Europe 2020 Agenda is to ensure the sustainable management of the natural resources and to fight against climate changes. Considering water to be not only a valuable natural resource for any type of landscape, but also the vital environmental component that ensured a minimum of productivity for the people working the unproductive salinization and gleyzation affected soils in the Jiu-Corabia enclosure, using embankment dams to breake the link between the Danube and the flood organism it created over a timespan of millenia has proven in the last 50 years to be an economic and ecological failure. Since the December 1989 events in Romania, after most of the socialist institutions have proven to be too resource consuming, thus unprofitable or maladaptive, the Jiu-Corabia locals have individually experimented with various land cultivation patterns, all of them based on draught-resistant crops, such as peanuts. In spite of it being the original natural landuse, lake usage has only been scarcely mentioned as a project after the 2006 flood, but after being institutionally rejected, its benefits in terms of ecological restoration, financial productivity have not been further looked into. The current article aims to identify different height level scenarios of lake usage in the Jiu-Corabia enclosure, using GIS technique. Lake volumes are calculated for each scenario with the aim of assessing the volume of water this enclose can absorb during flooding periods, as well as of estimating fish production for when the waters are low and it is not needed as a controlled flood chamber. Other benefits, such as providing a source of humidity for precipitations which will aid the crops nearby, have not been monetized, but contribute to the regional development efforts

Key words: *ecosystem services, environmental economics, GIS, Jiu-Corabia, floodplain, lake*

JEL Classification: *Q57 Ecological Economics: Ecosystem Services; Biodiversity Conservation; Industrial Ecology*

I. INTRODUCTION

The Danube is the sole major East-West water traffic axis that crosses Romania(***, 1969). Therefore, the Danube also becomes a polarizing factor for both settlements as well as agricultural, industrial and commercial activities, which have constituted the rationale for the numerous engineering works which have been implanted into the river’s course. The focused sector is mathematically located between the 23°54’30” and 24°30’30” Eastern longitude meridians and the 43°41” and 43°48” Northern latitude parallels (fig. 1), while geographically it belongs to the Danube floodplain south of the Oltenia plain, downstream the Jiu confluence, but upstream the Olt confluence.

The biggest impact work done in the Danube watershed is the embankment project, most of which has been completed in the 20th century, after extensive arguments between engineers led by Anghel Saligny and naturalists led by Grigore Antipa, the latter of who showed that while some sectors may be better capitalized on if they are put under embankment protections, for others it may mean the destruction of all productivity capacities.

The issue of embankment work done in the Danube floodplain has been brought back under the spotlight following the 2006 extreme hydrological evens, when the water has managed to break through the cracks and reclaim the extension of its former lakes as well as the marshes and other lands that used to be covered with water during floods (fig. 1). In April-May 2006, it has been proved that embanking a organism with a rapid dynamic in a tight corridor works only for preventing small and medium floods, but has an amplifying, destructive effect for bigger floods, seeing that once the embankment peak is crossed over, it has the effect of preventing gravitational flow of the water back into the river, trapping it. In these circumstances, the issue of ecological restoration becomes pivotal for hydrologists, biologists, pedologists, economists, engineers, special services workers as well as the government. Mass media has also played an important role in bringing to attention the issue of the ecological imbalances in this sector, naming the Dăbuleni area „Oltenia’s Sahara”.

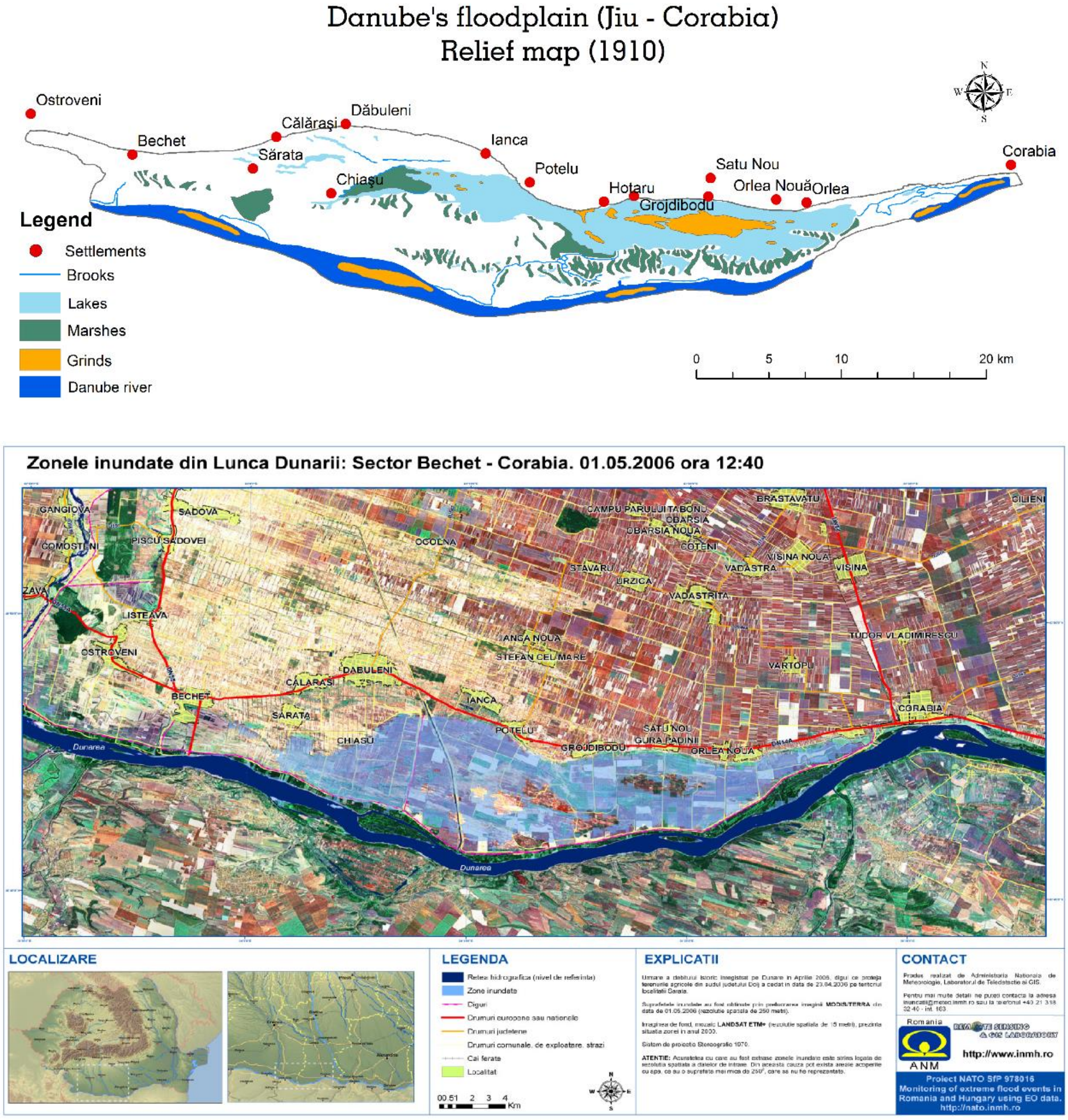

Fig. 1. The extent of the natural floodplain lakes in comparison to the extent of the 2006 flood (May 1st)
Source: inmh.ro

Moreover, following the 2007 ascension to the European Union, Romania has committed to the Union set objectives, amongst which the Rural Development policies have been pivotal. The 2014-2020 Rural Development policy (European Comission, 2015) focuses on three long-term strategic objectives:

- fostering the competitiveness of agriculture;
- ensuring the sustainable management of natural resources, and climate action
- achieving a balanced territorial development of rural economies and communities including the creation and maintenance of employment.

If the administration were to decide to act on the first objective for the study area, the results would be contrary to the second objective, seeing that antigravitational, energy and resource consuming irrigation systems would be necessary to ensure a competitive agriculture, thus grossly neglecting the sustainable management of natural resources. Such irrigation works are needed given the rough quartz sand litology, the superficial, undeveloped soils, the 548 mm average yearly rainfall and the 11,1°C average yearly temperature, which create the prerequisite for intense evapotranspiration.

Taking into consideration all the aforementioned natural, social and economical conditions, this paper has been started on the grounds that the original land use of lake is the optimum one and aims to contribute to the numerous arguments for such an usage.

II. METHOD

The present paper is based on GIS (Geographic Informational Systems) methods. For the below presented results, several steps were required, but they were not applied before consulting the relevant field bibliography, related to geological, geomorphological, biotic aspects, but also in connection to cultural and historical aspects. After the historical track of the area has been understood, the basic maps used for the analysis were generated from spatial data, using renowned GIS software ArcMap 10 and ArcScene 10 of the ESRI package.

Table no. 1. Primary spatial data used for the analysis

Data	Type	Source
Lakes, marshes, brooks, grinds, the Danube	Vector, polygon	Austrian maps of 1910 (scale 1:100.000)
Contour lines	Vector; polyline	Topographic map (scale 1:25.000)
Settlements	Vector; polygon	2005 Ortophotomap

Table no. 2. Generated maps used for the analysis

Map	Data used	ArcMap10 features used
Relief map (1910)	Polygons shapefile	Editing tools
Digital Elevation Model (DEM)	Contour lines	ArcToolbox – Spatial Analyst – Interpolation – Topo to Raster
Ideal Plane Slope	Contour lines	ArcToolbox – Spatial Analyst – Interpolation – Topo to Raster

Once the input analysis materials have been generated using ArcMap10, they were exported into ArcScene10, where several scenarios were simulated. The ideal plane slope is the artificially created slope of the proposed water surface that occurs due to the gravitational force. Using ArcScene10, the ideal plane slope has been elevated 1, 2, 3, 4, 5, 6, 7, respectively 8 meters above the minimum heights of the studied sector, which results in 8 intersections with the digital elevation model (DEM), which has previously supported an exaggeration factor in order to tridimensionally represent the terrain surface. The resulted visible surface (fig. 2) is the simulated lake in 8 different stages, if no additional flatwork is done.

Admittedly, the same method can be used by the authorities in order to increase the sector’s resilience to a new flood. By simulating new „lakes” with the water surface above 30 m (more than 8 m above the minimum altitude point of the area), the vulnerable areas can be identified. As the water will occupy the lowest areas first, the gradual simulations will show which areas will be flooded first and in which direction will the flood occupy new areas, therefore investing in protecting those areas better.

The evaluation of the two types of soils in the region has been done using certified I.C.P.A. (Institute of Pedological and Agrochemical Research) methods (I.C.P.A., 1987), giving marks ranging from 0,1 to 1 to 18 physical and chemical indicators.

III. RESULTS AND DISCUSSIONS

For the 8 simulation scenarios, 8 lake usage maps have resulted (fig. 3). For each of these scenarios the water surface, water volume and fish production capacity have been calculated (table 3), the latter of which has been estimated based on an average carp production of 0,5 tons/ha. However, cases in which the fish production has greatly surpassed that figure have been documented, frequently private administrators boasting figures up to 3 tons/ha.

Table no. 3. Simulation results

Lake level [m]	Lake surface [m^2]	Lake volume [m^3]	Estimated annual fish production [t]
23	72162274	36546427	36
24	97567440	121966457	48
25	152261660	374630181	76
26	188665279	417851514	94
27	196580763	610510500	98
28	215581080	817156846	108.5
29	221915684	1036463338	111
30	231626085	1261375786	115.5

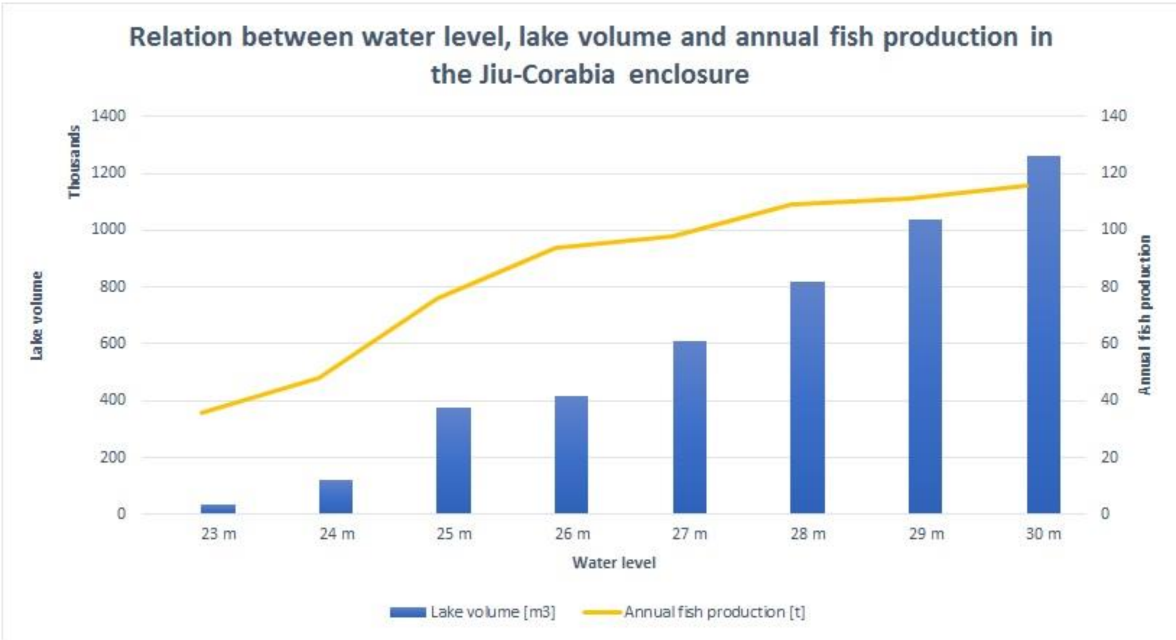

Fig. 2. Relation between water level, lake volume and annual fish production of the proposed lake scenarios in the Jiu Corabia enclosure

Furthermore, the suitability of the Jiu-Corabia enclosure for lake usage is enhanced by the unsuitability of the same sector for agricultural performance.The evaluation marks for two of the typical floodplain soils of the region show that the sand based soils (*psamosol*) fall into the 4th quality class, while the soils formed on flood deposits (*aluviosol*) fall into the 5th quality class (out of a total of 5 quality classes of the Romanian classification). Therefore, even if the land use does not become that of a lake, the most productive land use is for pasture (38,9, respectively 41,5 evaluation marks out of a maximum score of 100). Additionally, the lake would create the conditions for enhanced precipitation in the region (Antipa, 1910), which would benefit crops in the vecinity, as the evaporation would condensate over the agricultural lands.

Even financially, the lake functioning in the Jiu-Corabia enclosure would be more profitable than continuing to grow wheat and maize with a 1284,7 RON/ha productivity, as opposed to 2579,2RON/ha in Brăila county or 1894,2 RON/ha in Giurgiu county (INDD, 2008). Besides the low productivity index, the old technology embankments need a 382.464 RON investment for cant works and a 13.307.378 RON investment for additional earthworks per 5 kilometers, which, proportionally, would rise the total investment to 134.160.451 RON/30.280.425 Euros for the entire length of the sector. In addition to the embankment investments needed in this enclosure, several similar investment projects are needed for the more fertile lands downstream Corabia, whereas transforming the sector in a lake/controlled flood chamber would generate profit from fish when the Danube levels are in normal parameters and would help protect as well as minimize flood risk management costs downstream when the Danube waters reach critical levels, by absorbing part of the flood and mitigating the flood wave.

Analyzing table no. 3 and figure 3, it becomes clear that a lake level over 26 m would affect the Chiaşu settlement (fig. 3). At the same time, the best water volume/fish production ratio is also reached in the 26 m scenario (fig. 2). The decision to change the land use of the study sector from partly-irrigated agricultural lands to a lake/reservoir that could double as a controlled flood chamber has to be done by a board of stakeholders from diverse media, ranging from public administration to researchers, the civic society (NGOs), the private sector and the local population. The first proposal of this kind came from a former Minster for the Environment and Water Management right after the 2006 floods.

Currently, the European and Romanian legislation allow a switch from an artificially sustained agricultural land use to a lake usage, one of the European priorities being *„restoring, preserving and enhancing ecosystems related to agriculture and forestry”*. However, political and economic struggles have prevented the community and interested institutions to capitalize on the opportunity that arised during the 2006 floods and transform the entire close embankment enclosure in an engineering system that allows the supply, the storage as well as the discharge of water, according to the needs and natural water levels from upstream.

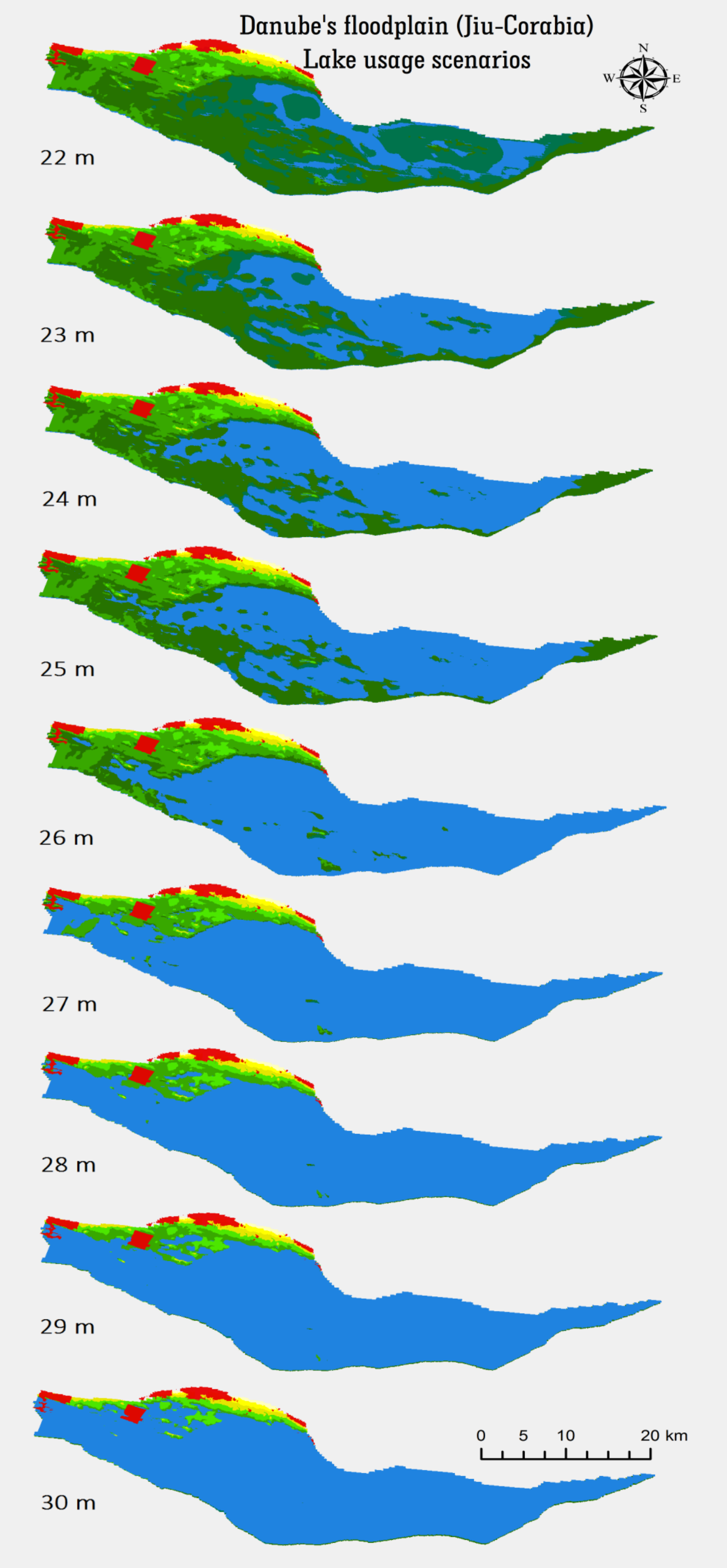

Fig. 3. Lake surface simulations in the Jiu-Corabia enclosure for water level scenarios ranging from 22 to 30 m if no ground leveling work is previously done

IV. CONCLUSIONS

The Jiu-Corabia enclosure is known for once benefitting from state-of-the-art irrigation systems, which proved to be unsustainable in the long run. The 2006 flood made the river's destructive power available for the authorities' decisions, but the decision to keep an outdated, resource and energy consuming land use which is contrary to the natural conditions was made. The lake usage for the Jiu-Corabia sector seems to be optimum when filled up to the 26 m level. The lake would not only generate moisture and rainfall for the neighbouring crops, but would also provide eco-tourism (*green money*) and fishing income sources for the locals, aiding flood management initiatives for the very productive agricultural enclosures downstream.

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